THE EFFECT OF BIOCHAR ON GROWTH AND YIELD OF WHEAT PLANT UNDER DROUGHT CONDITIONS

By

WESAM MANSOUR AHMED NEGM
B.Sc. Agric. Sc. (Botany), Ain Shams University, 2013

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ABSTRACT

Wesam Mansour Ahmed Negm: The Effect of Biochar on Growth and Yield of Wheat Plant Under Drought Conditions. Unpublished M. Sci. Thesis, Agric. Botany Department, Fac. of Agric., Ain Shams Univ., 2019.

Implementation of adaptive measures to resilience agroecosystems to drought is one of the key tasks of green biotechnology to sustain crop yields. Recently, biochar soil amendment has emerged as a feasible win-win strategy to enhance crop productivity, especially under limited water availability, and to mitigate greenhouse gasses emission. This study aimed, therefore, to determine the effects of biochar soil application on the growth, development and yield of wheat (*Triticum aestivum* L.) plants grown under different water regimes. A completely randomized greenhouse pot trial was conducted using three levels of biochar addition (0, 2 and 5% BC) to a sandy soil under different water regimes [60%, 30% and 15% of the soil water holding capacity (WHC)]. Overall, growth-related parameters measured in this study were negatively influenced by drought, the effect that was more pronounced at 15% WHC. Drought stress decreased the total plant biomass by 65% and 72% at moderate and severe drought stress treatment, respectively, compared to well-watered controls. The number of tillers per plant was significantly reduced by 66% and 73%, and that of the leaves by 58% and 74% in plants grown at 30% and 15% WHC, respectively. Leaf area per leaf was also reduced, being only 62% and 56% of that of the controls at moderate and severe drought stress, respectively. Drought-induced growth inhibition was associated with an impaired plant water balance (indicated by lower LRWC and ψ_s), ion imbalance (indicated by reduced K^+, relatively lower N and higher Mg^{2+} and Ca^{2+} contents), reduced photosynthetic pigments, enhanced LEL and higher proline concentrations in both the root and shoot tissues. Water stress markedly decreased all yield-contributing parameters, leading consequently to

reduce the grain yield per plant by 70% and 97% at moderate and severe water stress, respectively, compared to well-watered controls.

BC soil application at either 2% or 5% substantially improved wheat growth and productivity, both under sufficient and limited water supply. At ample water regime, BC resulted in substantial increases of about 183% and 100% in total plant biomass when applied at 2% and 5%, respectively, compared to non-amended controls. BC-induced improvements in plant biomass were coincided with significant increases in plant height and numbers of tillers and leaves per plant. Most interestingly, BC-treated plants showed conspicuous growth even under severe drought conditions, confirming the potential of BC in enhancing plant drought resistance. BC applied at 2% increased the plant biomass by up to 400% and 80% at moderate and severe water stress treatments, respectively, compared to un-amended controls. Similarly, BC applied at 5% led to increase the plant fresh weight by 220% and 58% at moderate and severe drought stress treatment, respectively. The beneficial effects of adding BC were also manifested by 137% and 107% increases in the grain yield (GYPP), when BC was applied at 2% or 5%, respectively, under normal irrigation treatment. The interactive effect of drought and BC treatments was highly significant, as BC application at 2 and 5% increased the GYPP by roughly 317% and 308%, respectively, for plants exposed to moderate water stress. Under severe drought, BC applied at 2 and 5% caused up to 6.7 and 1.6 folds increases in the GYPP, respectively. Taken together, these results indicate that 2% BC could be an optimal level to sustain wheat growth and productivity, at least under our experimental conditions, both under ample and limited water supply. BC-mediated growth stimulation might be attributed to its positive effects on the physical and chemical properties of the soil (improved soil WHC, and nutrient contents). This ultimately contributed to an enhanced plant water status (higher ψ_s and LRWC) as well as a better plant nutrient uptake (mainly, K^+, Mg^{2+} and N contents). Our results indicated clearly that drought-induced disorders in plant growth, physiology and hence

productivity of wheat could be ameliorated by BC soil application, with 2% BC was most effective, particularly at severe drought stress conditions. These results justify the potentials of biochar as a novel approach for improving wheat productivity and could be considered as a step forward for its use to sustain crop production, particularly, at marginal areas of Egypt.

Keywords: Wheat, Drought, Biochar, Soil amendment, Plant growth, Grain yield, Water balance, Nutrients, Osmotic adjustment, Photosynthetic pigments

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LIST OF ABBREVIATIONS

ABA	Abscisic acid
AMF	Arbuscular mycorrhizal fungal
APX	Ascorbate peroxidase
ARC	Agriculture research center
BC	Biochar
CEC	Cation exchange capacity
Chl(a)	Chlorophyll (a)
Chl(b)	Chlorophyll (b)
Cks	Cytokinins
Ctr.	Control
DW	Dry weight
EC	Electrical conductivity
FW	Fresh weight (Weighed instantly)
GA3	Gibberellic acid
GB	Glycine betaine
GHG	Greenhouse gases
GR	Glutathione reductase
GYPP	Grain yield per plant
IAA	Indole acetic acid
IBI	The International Biochar Initiative
ICP	Inductively coupled plasma atomic emission spectrophotometer).
LEL	Leaf electrolyte (ion) leakage
LHC	Light-harvesting complex
LMA	Leaf mass to area ratio
LRWC	Leaf relative water content
MD	Moderate drought
OA	Osmotic adjustment
PAs	Polyamines
PEP	Phosphoenol pyruvate
PGRs	plant growth rehulators